ARCTIC ICE ALGAL BIO-OPTICS & SEA ICE SEDIMENTS

Glenn F. Cota
Center for Coastal Physical Oceanography
Old Dominion University
Norfolk, VA 23508
Phone: 757-683-5835 Fax: 757-683-5550 E-mail: cota@ccpo.odu.edu
Award #: N000149610326

LONG-TERM GOALS

The goals of this research are to improve our understanding of bio-optical variability, primary productivity, and the influence biogenic and nonbiogenic materials on heat flux in polar marine ecosystems. The data are being used in radiative transfer, thermo-optical, bio-optical productivity models.

OBJECTIVES

The main scientific objective is to understand the influence of ice algae and other inclusions on the apparent and inherent optical properties of sea ice systems. Quantitative relationships between optical, physical, biogeochemical and biological variability are being sought. The influence of biogenic and nonbiogenic materials on the heat budget of sea ice is being explored.

APPROACH

Basic methodology has been described in detail previously. Stratified in situ spectral transmission measurements were made throughout snow, sea ice, the bottom ice algal layer and subice. This approach maintains natural distributions of the snow, ice, water and inclusions, largely eliminating potential artifacts due to geometrical changes. Comparative in vivo observations were made by determining absorption spectra for particulate and dissolved materials in discrete samples from all layers. Sea ice data were obtained from Resolute, NWT (1993 & 1995) and Barrow, AK (1994). Absorption by sediments from sea ice and the benthos is also being examined from a number of locations; this effort is ongoing. Sediment samples have been collected at sites in the Canadian Archipelago and the Barents, Beaufort, Bering, Chukchi, Kara and Laptev Seas. Multilayered spectral models are being used to examine the relative contribution of ice algae and other inclusions to light transmission and the heat budget.

WORK COMPLETED

Except for additional sediment samples collected by foreign colleagues, all experimental and ancillary field data have been tabulated and reduced to final form with graphical summaries. Results have been presented at ARI and AGU meetings and seminars. Collaborative efforts are in progress to compare, synthesize and model data. Three papers have been submitted for publication and five to six others are in preparation.

RESULTS

Report Documentation Page

Report Documentation Page	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **Arctic Ice Algal Bio-optics & Sea Ice Sediments**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Old Dominion University,Center for Coastal Physical Oceanography,Norfolk,VA,23529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

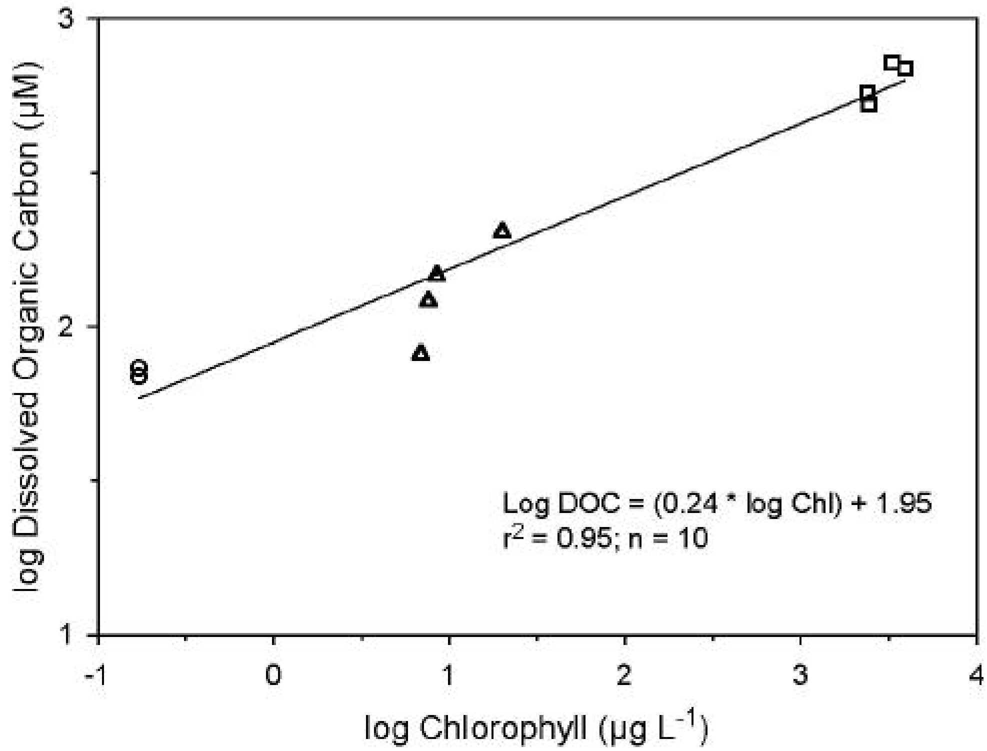
13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18



Results from the Sea Ice Electromagnetic field program at Barrow clearly show that the bottom ice algal layer attenuates much more strongly than bulk sea ice (Perovich et al. 1997). Attenuation coefficients over the algal layer are comparable in magnitude to snow values, except there is strong absorption in the chlorophyll absorption peaks in the blue and red. Biomass levels at Barrow, Alaska are 10-30 times lower than at Resolute Bay, NWT, Canada. Both measured and modeled attenuation for the bottom ice algal layer was greater than the relatively opaque upper transition layer dominated by unaligned frazil ice crystals (Mobley et al. 1997). Even with relatively little chlorophyll biomass at Barrow attenuation by the algal layer was almost fivefold higher than interior congelation ice.

Dissolved organic materials can be greatly elevated in landfast, first-year sea ice with heavily colonized bottom ice algal layers (Cota et al. 1997). Concentrations of dissolved organic carbon (DOC) were strongly correlated to chlorophyll concentrations in seawater, interior sea ice and bottom sea ice (Fig. 1). Colored dissolved organic material (CDOM) was also abundant in sea ice. CDOM from sea ice absorbs strongly in the ultraviolet (UV) and blue regions of the spectrum (Fig 2). Characteristic absorption peaks were found around 205 nm and 275 nm. Bottom ice algae absorbed most strongly near 265 nm in the UV and dominated visible absorption. Spectrally-averaged absorption of CDOM over the UV and visible (200-700 nm) was related to DOC concentration (Fig. 3), but the relationship may not be strictly linear.

Figure 1. Linear regression of log dissolved organic carbon concentration (µM) versus log

chlorophyll concentration (μg l^{-1}) for surface seawater (circles), interior sea ice (triangles) and bottom sea ice (squares). The scales are logarithmic because the chlorophyll data span over four orders of magnitude.

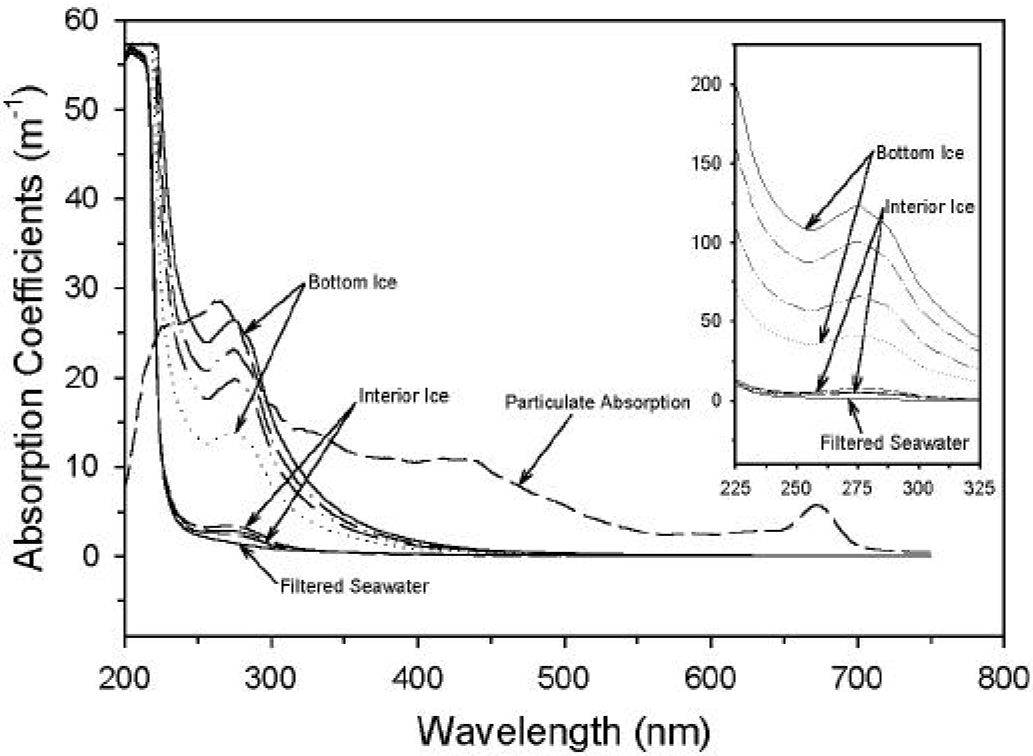


Figure 2. Soluble and particulate absorption coefficients (m^{-1}) over the ultraviolet, visible and near infrared from 200-750 nm for filtered seawater (n = 1), interior sea ice (n = 4) and bottom sea ice (n = 4) and bottom ice particulates (n = 1). The arrows for bottom and interior ice point to the lowest and highest soluble absorption spectra. The particulate spectrum is from a bottom ice sample with a similar amount of algal chlorophyll and is shown for comparison. All soluble coefficients in the main panel of were not corrected for dilution by filtered seawater. The inset shows volume corrected values, which are about five times higher, for the UV region of interest (see Cota et al. 1997 for details).

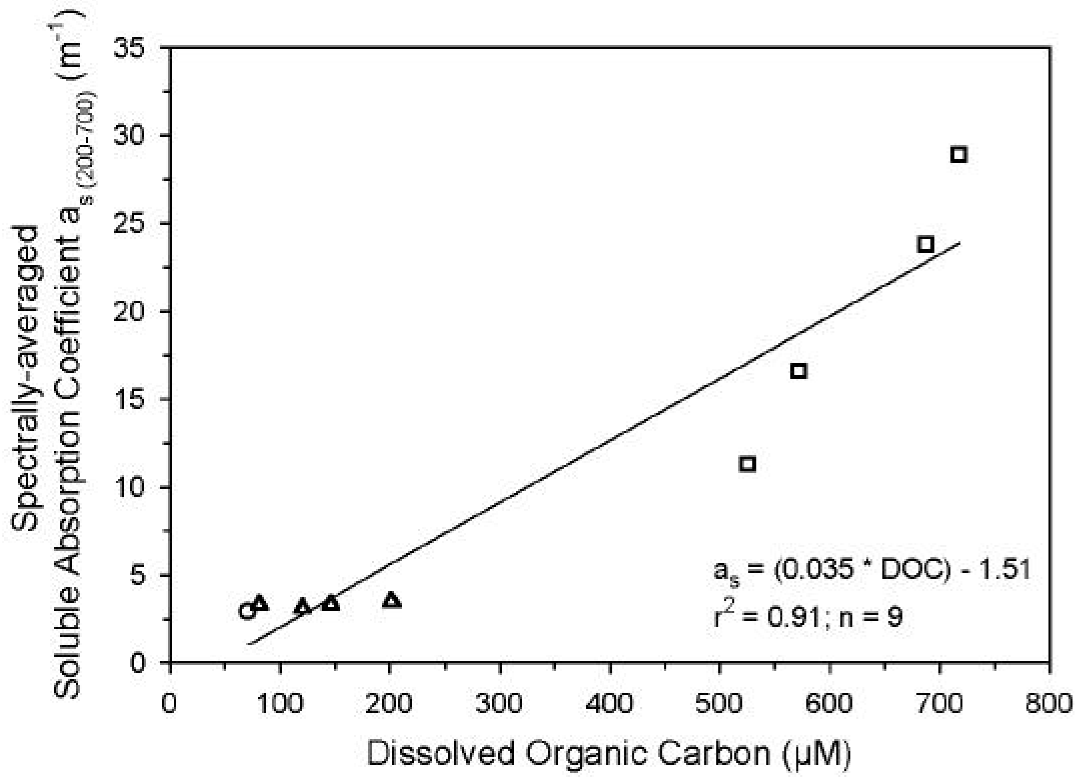


Figure 3. Linear regression of spectrally-averaged soluble absorption coefficients $a_{s(200-700)}$ (m^{-1}) for the ultraviolet and visible (200-700 nm) versus dissolved organic carbon concentrations (µM) for seawater (circle), interior sea ice (triangles) and bottom sea ice (squares).

IMPACTS/APPLICATIONS

Photosynthetic action spectra of ice algae and related absorption spectra for dissolved and particulate (biogenic and sedimentary) materials will provide a benchmark for bio-optical modeling of sea ice systems.

TRANSITIONS

Data have been made available to collaborators mentioned below.

RELATED PROJECTS

Collaborations are ongoing with D. Perovich, C. Roesler, R. Maffione, C. Mobley, D. Barber, T. Grenfell and R. Iturriaga on various aspects of sea ice and snow bio-optics.

REFERENCES

Cota, G.F., W.G. Harrison and P. Kepkay. 1997. Dissolved organic material in sea ice:

Biogeochemical implications and bio-optical properties. J. Geophys. Res. (submitted).
Mobley, C.D., G.F. Cota, T.C. Grenfell, R.A. Maffione, W.S. Pegau and D.K. Perovich, 1997. Modeling light propagation in sea ice. IGARS (submitted).
Perovich, D.K. et al. 1997 Field Observations of the electromagnetic properties of first-year sea ice. IGARS (submitted).